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ROOTING RESPONSE OF SELECTED CITRUS SP. TO APPLICATION OF DIFFERENT HORMONES

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ABSTRACT

The study analyzed on selected citrus species stem cutting on rooting response. Different rooting hormones (IBA, IAA, NAA, Hormex and Saredex) were used for cuttings at the recommended rate and 6 morphological characteristics were generated and detected after 60 days.

Interaction effects between citrus species and rooting hormones in all parameters were not significant but hormone and citrus mean had significant effects in all parameters except on days to shoot, number of shoots, number of leaves and number of roots. Rooting performance of citrus species performed better and improved when used of any hormones (NAA, IAA, IBA and Hormex).

The result of the study clearly showed that the use of any rooting hormones especially Naphthalene Acetic Acid (NAA) can enhance the rootability of selected citrus species (Calamansi. Calamandarin and Dalandan) as early as than 60 days.

INTRODUCTION

Citrus fruits have nutritive value that gave strength and have medicine for some illnesses and it has important to be daily consumption of our body diet. Citrus has different shapes that are rich in vitamin C that needed for our human body, the taste is usually sweet but occasionally sour. In the Mediterranean centuries, some citrus species mostly exist such as orange, mandarin and lemon trees establishing citrus best in good soil and climatic conditions that can achieve a high level of fruit quality than other regions.

Cutting is often the preferred method of propagation in horticulture since it is cheap, fast, and modest technology and no skill is needed unlike in grafting, budding or micro-propagation. For citrus, as many fruit crops, this method is necessary not only to maintain desirable characteristics of the mother plant (Hartmann *et al.*, 1983), but also to provide them with desirable quantities of true-to-type rootstocks. This fact may be of great importance since rootstocks are known to affect many scion characteristics such as vigor, yield, and fruits quality and disease resistance, conditioning therefore the success of citrus industries (Espinoza-Nunez *et al.,* 2011). Furthermore, it is reported that cutting has the tendency to decrease the juvenile stage of plants and reduce the time of nursery development (Spiegel-Roy, 1996). According to (Sabbah, et al. 1991) rootstock through cuttings can produce the same quality, uniform in size, good characteristics of the mother plants and production is faster and rapid to meet the demand. Like tissue culture plantlet, tissue culture production protocol is not easy and warrant for is it takes time to develop protocols and sufficient size to warrant in variety trial testing.

Therefore, an alternative method in propagating citrus should be explored. One method is the use of stem cutting through rooting of terminal stem. The hormone that aids the growth of adventitious roots is called auxin, however analytical forms of auxins like Indole Butyric Acid (IBA), Indole Acetic Acid, Naphthalene Acetic Acid (NAA), Hormex, and Saredex are commercially available. This study, therefore, aimed at determining the most appropriate rooting hormone solutions for propagating stem cuttings of citrus and growth performance of citrus cutting applied with nitrogen fertilizer.

A study of stem cutting of citrus species was conducted at University of Southern Mindanao, Kabacan, Cotabato. The research aimed to evaluate the effects of different rooting hormones application on the rootability of citrus cuttings. The research was composed of two studies; first study focused on using different rooting hormones that enhance callus and rooting formation of the citrus and second, application of nitrogen fertilizer on different rooted citrus species cutting under potting condition.

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MATERIALS AND METHODS

Experimental Design and Treatments

Double Factor Completely Randomized Design (CRD) was used with six treatments replicated three times. Sixty (60) sample cuttings were used per treatment. Semi-hardwood stem cuttings of citrus species served as Factor A while different rooting hormones served as Factor B. The following treatments were used:

Factor A (Species)	Factor B (Hormones)
S_1 - Calamansi	T1 – Control (water only)
S_2 - Calamandarin	T2– IBA (1000ppm)
S_3 - Dalandan	T3– IAA (1000ppm)
	T4– NAA (1000ppm)
	T5– Hormex (pure solution)
	T6 – Saredex (pure solution)

Preparation of the Experimental Area

The experimental set up situated in a partially shaded area or not directly exposed to sunlight to prevent the experimental cuttings from stress.

Rooting Media Preparation

River sand and coir dust were used as the rooting media. The sand and coir dust were thoroughly sieved. The sand was mixed with coconut coir dust with a ratio of 1:1 before placing them to the polyethylene bag measuring 4 x 6 x 0.02 cm. The river sand and coir dust were disinfected by pouring with fungicide. One thousand eighty (1,080) polyethylene bags filled with ¾ mixtures of river sand and coir dust were used. The polyethylene bags were arranged according to the design and layout of the experiment. The chamber was covered with a thick sheet of polyethylene suspended on a wire frame to maintain moisture from 80 to 90 percent. When covered with a clear plastic bag, stem cutting about 3 to 4 inches would root.

Selection and Preparation of Citrus Stem Cuttings

Proper and careful selection of experimental plants was done in order to get or produce the experimental samples. The mother plant, where the
sample stem cuttings were taken was healthy and already bearing and free from any disease infestation. Healthy stem cuttings were selected and then carefully cut or harvested early in the morning by using sharp pruners and leaves were cut by half to reduce transpiration. These cuttings were transported and handled properly from the source to the experimental area and planted within the same day.

Preparation of Rooting Hormone Solutions

The different rooting hormone solutions used as treatments were prepared following the recommended rate. One thousand part per million (1000 ppm) of each hormone namely; Indo Butyric Acid (IBA), Indole Acetic Acid (IAA) and Naphthalene Acetic Acid (NAA) were measured, weighted and diluted to one liter of water while Hormex and Saredex used the pure solution for each hormone.

Treatment of Stem Cuttings with Rooting Hormone Solution

The basal portions of the prepared sample stem cuttings were dipped for 10 minutes in separate plastic containers in different rooting hormones. At least 2.5 cm of the stem cuttings were depth in the different solutions based on the specific treatments.

Planting of Citrus Cuttings

The treated cuttings were planted into prepared potting media by inserting the basal portion of the stem cuttings. Sixty (60) sample stem cuttings per treatment were planted with at least 5 cm deep into the soil media .

Care and Maintenance

Experimental plants need proper care and maintenance. The chamber maintained 80% to 90% humidity to ensure enough moisture. Depending on the weather and moisture condition of the soil, a 250 ml of water was added. Weeding was done regularly to minimize competition of nutrients, water and sunlight.

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Data Gathered

Number of days to shoot formation. This was gathered from the 10 sample plants by counting the number of days from the time of planting until the emergence of the first shoot.

Number of shoots. The number of shoots was gathered from the 10 samples plants upon termination of the study or 60 days after treatment. The number of shoots per sample cutting was counted individually.

Length of shoot. The length (cm) of newly developed shoots was measured from the 10 sample plants using a ruler. The measurement was done upon termination of the study or 60 days after treatment.

Number of leaves. This was taken from the 10 sample plants by counting and recording every noticeable leaf on each plant, including the new leaves just beginning to emerge. This was counted upon termination of the study.

Number of roots. The number of roots was gathered from the 10 sample plants upon termination of the study or 60 days after treatment by carefully uprooting the rooted cuttings and then washing and counting the roots. The number of newly developed primary roots per sample cutting was counted individually.

Length of roots. The length (cm) of newly developed primary roots was measured from the 10 sample plants using a ruler after uprooting the cuttings, washing the roots. The measurement was done upon termination of the study or 60 days after treatment.

Percentage rooting. The percentage **(%)** rooting was gathered from the 10 sample plants upon termination of the study or 60 days after treatment the cuttings by counting the number of rooted cuttings..

Percentage survival. The percentage **(%)** survival was gathered from the 10 sample plants upon termination of the study or 60 days after treatment the cuttings. The percentage was computed using the formula:

$$Percentage\ (\%)Survival = \frac{\text{Number of rooted cuttings}}{\text{Total number of cuttings}} x\ 100$$

Other observations. Aside from the above data or parameters, other observations were also noted and recorded. Photo documentation was done.

Number of Rotted citrus cutting**.** **T**he number of rooted cuttings observed at 30, 45 and 60 days after treatment. Three (3) sample cuttings were uprooted (destructed) to get the number of rooted cuttings

Temperature and Relative Humidity. The temperature and relative humidity readings were taken for three months using hygrometer. Three separate recordings were taken every day

RESULTS AND DISCUSSION

Number of Days to Shoot Emergence

Statistical analysis revealed that the number of days to shoot emergence was not significantly affected by selected citrus species and rooting hormones as presented in Table 1. Regardless of different rooting hormones, there was no different effect found out. The cuttings treated with NAA formed earlier shoot at 19.17 days and the untreated cuttings produced shoots at 23.63 days. The citrus species were significantly different from each other in term of days to shoot emergence. Calamansi cutting formed shoots as early as 16.35 days, followed by Dalandan with the mean of 21.28 days and the latest formed shoots were found in Calamandarin with mean of 26.07 days.

Citrus species can form shoot as early as possible with application of hormones. Research studies conducted by Calvo (1998 and 1999) in lanzones cuttings showed an early shoot development in hardwood than semi hardwood cuttings treated with 400 and 500 ppm ANAA, respectively. In this study, it has been observed that cuttings treated with hormones formed shoots earlier that it was assumed that active buds were present on the said cuttings and their growth may be stimulated or encouraged.

According to Sun and Bassuk (1993), the application of synthetic auxin to stem cuttings at high concentration can inhibit bud development, sometimes to the point at which no shoot growth will take place. Wareing and Philips (1981) found that hormones, like auxin, gibberellins and cytokinins play a vital role in the control of growth not only within the plant as a whole, but apparently, also within individual organs.

Number of Shoots

There was no significant effect between different citrus species cutting and different rooting hormones on number of shoots developed per cutting shown in (Table 2,. Regardless of the selected citrus sp. cuttings and different rooting hormones treatment, the number of shoots developed per cutting mean ranged from 1.63 to 1.88 shoots. Result showed that Calamansi produced the greatest number of shoots with a mean of 2.10 shoots and the

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least was found in Calamandarin with a mean of 1.40 shoots. However, analysis of variance was not significant between citrus species.

Table 1. Number of days to shoots emergence of selected citrus species stems cuttings applied with different rooting hormones 60 days after planting.USM, Kabacan, Cotabato, 2019.

Hormones	Citrus Cutting			B-Mean^{ns}
	Calamansi	Calamandarin	Dalandan	
Control	17	28.1	25.8	23.63
IBA	18.5	23.4	19.1	20.33
IAA	16.6	27	22	21.87
NAA	15.3	24.7	17.5	19.17
Hormex	13.9	25.8	23.7	21.13
Saredex	16.8	27.4	19.6	21.27
A- Mean[1/]	16.35^{a}	26.07^{c}	21.28^{b}	**21.23**
C.V. - %	19.48			

[1/] Means of citrus species of with the same letter superscript are not significantly different at 5% level of significant (Tukeys-test)
ns - not significant

Table 2. Numbers of shoots of selected citrus species stem cuttings applied with different rooting hormones 60 days after planting. USM, Kabacan, Cotabato, 2019.

Hormones	Citrus Cutting			B-Mean^{ns}
	Calamansi	Calamandarin	Dalandan	
Control	2.21	1.33	1.35	1.63
IBA	2.09	1.25	2.10	1.81
IAA	2.43	1.30	1.53	1.75
NAA	1.73	1.10	2.67	1.83
Hormex	2.44	1.43	1.77	1.88
Saredex	1.71	1.97	1.57	1.75
A- Mean^{ns}	2.10	1.40	1.83	**1.78**
C.V. - %	27.14			

ns- not significant

Length of Shoot

There was no significant interaction effect between citrus species and rooting hormones on the length of shoots (Table 3). Application of rooting hormones showed significant difference in terms of length of shoots. Indole Acetic Acid (IAA) produced the longest shoot with a length of 3.32 cm which was significantly different from the control and the shortest shoot length of 2.37 cm was found in untreated cuttings but IAA was comparable to the rest of rooting hormone (IBA, NAA, hormex and saredex) while NAA, IBA, hormex and saredex were comparable to untreated cuttings. Moreover, selected citrus species has significantly difference between treatment mean. Calamansi and Dalandan had no significant different term of length of shoots but significantly longer than Calamandarin.

Mancera (2013) reported that in calamansi cuttings, the application of 200 ppm ANAA promoted the development of more leaves and hardwood cutting developed longer shoots. Seran and Umadevi (2011) noted that

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lemon stem cuttings had higher shoot length (5.73 cm), rooting percentage (73.33 percent) and survival rate (90.0 percent) when treated with 3000 ppm IBA under sand medium.

Number of Leaves

The data presented in Table 4, (Plates 5, 6, 7) show no significant interaction effects between selected citrus species and rooting hormones on the number of leaves. Different rooting hormones did not significantly affect the number of leaves; hormones mean ranged from 5.25 to 6.76. However, selected citrus species were significantly influenced by rooting hormones. Calamansi formed the most number of leaves with 8.19 leaves, which was significantly different from Dalandan which formed 5.65 leaves and Calamandarin with 4.99 leaves. However, Dalandan and Calamandarin were comparable to each other.

Cited by Cordon (2006), the research studies conducted by Calvo (1998 and 1999) in lanzones cuttings showed an early shoot development in hardwood than semi hardwood cuttings treated with 400 and 500 ppm ANAA, respectively. In this study, it has been observed that cutting treated with hormones formed shoots earlier, it was assumed that active buds were present on the said cuttings and their growth may be been stimulated or encouraged.

Wareing and Philips (1981) found that hormones, like auxin, gibberellins and cytokinin play a vital role in the control of growth not only within the plant as a whole, but apparently, also within individual organs

Table 3. Length (cm) of shoots of selected citrus species stem cuttings applied with different rooting hormones 60 days after planting. USM, Kabacan, Cotabato, 2019.

Hormones	Citrus Cutting			B-Mean[1/]
	Calamansi	Calamandarin	Dalandan	
Control	3.28	1.5	2.34	2.37[b]
IBA	3.07	2.41	3.32	2.93[ab]
IAA	3.44	3.06	3.46	3.32[a]
NAA	3.23	2.57	3.45	3.08[ab]
Hormex	2.9	2.52	3.39	2.94[ab]
Saredex	3.31	1.95	2.89	2.72[ab]
A- Mean[1/]	3.21[a]	2.34[b]	3.14[a]	2.89
C.V. - %	19.19			

[1/] Means of rooting hormones with the same letter superscript are not significantly different at 5% level of significant (Tukeys-test)

[2/] Means of citrus species with the same letter superscript are not significantly different at 5% level of significant (Tukeys-test)

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Table 4. Number of leaves of selected citrus sp. stem cuttings as applied with different rooting hormones 60 days after planting. USM, Kabacan, Cotabato, 2019.

Hormones	Citrus Cutting			B-Mean[ns]
	Calamansi	Calamandarin	Dalandan	
Control	8.44	3.72	3.6	5.25
IBA	8.86	4.75	6.37	6.66
IAA	9.77	5.08	5.23	6.69
NAA	6.86	5.07	8.2	6.71
Hormex	8.78	5.79	5.7	6.76
Saredex	6.44	5.55	4.8	5.6
A- Mean [1/]	8.19[a]	4.99[b]	5.65[b]	**6.28**
C.V. - %	26.87			

[1/] Means of citrus species with the same letter superscript are not significantly different at 5% level of significant (Tukeys-test)
[ns] – not significant

Number of Roots

The data Table 5, (Plate 5, 6, 7), that there were no significant interaction effects between selected citrus species and different hormone on the number of roots. The result revealed that different rooting hormones affect the number of roots of selected citrus species stem cuttings. After 60 days of treatment, number of roots produced from 1.57 to 2.93 roots. IBA was significantly different from the control but comparable to IAA and NAA. Hormones like IAA, NAA and hormex were comparable to each other and also IAA, hormex and saredex were not significant to each other. Also observed, that there was no significant difference on number of roots in selected citrus species. Number of roots produced range from 2.03 to 2.40.

Based on the data presented, the application of hormone can improve the number of roots and prolonging the period of collection of data can improve the number of roots. Rooting of cuttings would not be due to hormone treatment but interaction of factors in the stem and the environmental condition may also be considered. According to Mancera (2013), 200 ppm ANAA is good enough to initiate development of roots of calamansi cuttings 90 days after treatment of hormone. The possibility of higher amount of endogenous auxin accumulated of cuttings and its effective response to synthetic hormone treatment favor the development of roots. While Hartmann *et al.*, (1983) reminded that auxin treatment is not an absolute guarantee for root formation they further emphasized that physiological as well as environmental conditions of the stocks play an important role in the process. Bhatt and Tomar (2011) reported that the maximum root formation, root length, root diameter, and shot sprout were recorded in citrus cuttings below 500ppm IBA concentration.

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Table 5. Number of roots of selected citrus species stems cuttings as applied with different rooting hormones 60 days after planting. USM, Kabacan, Cotabato, 2019.

Hormones	Citrus Cutting			B-Mean [1/]
	Calamansi	Calamandarin	Dalandan	
Control	1.57	1.29	1.86	1.57[d]
IBA	3.17	2.94	2.67	2.93[a]
IAA	2.32	2.47	2.53	2.44[abc]
NAA	2.00	3.26	3.23	2.83[ab]
Hormex	1.61	2.18	2.40	2.06[bcd]
Saredex	1.5	2.06	1.70	1.75[cd]
A- Mean [ns]	2.03	2.37	2.40	**2.26**
C.V. - %	25.03			

[1/] Means with the same letter superscript are not significantly different at 5% level of significant (Tukeys-test)
ns – not significant

Length (cm) of Roots Per Cutting

The analysis of variance revealed no significant interaction effects developed between different citrus species stem cuttings and hormones, 60 days after treatment as shown in Table 6,. There was a significant effect on treatment means on length of roots. NAA hormones had the longest root length with 4.51 cm that was significantly different from the control which had the shortest root length of 2.33 cm. However, all rooting hormones were comparable but Saredex, IAA and IBA were the same to the control. On the other hand, length of roots of selected citrus species had significant difference on mean. Calamansi had the longest root length of 4.84 cm which was significantly different to Calamandarin and Dalandan, but the last two citrus species were comparable. Moreover, Dalandan produced shortest root length.

Cited by Marcera (2013), 200 ppm ANAA is enough to initiate calamansi cuttings root growth 90 days after hormone treatment. The possibility of higher quantities of endogenous auxin accumulated from cuttings and their effective response to synthetic hormone treatment favored to root development and encouraged the development of more leaves and longer shoots developed from hardwood cutting. While Hartmann *et al.*, (1997) recalled that treatment with auxin is not an absolute root formation guarantee. They also stressed out that stocks physiological and environmental conditions play a significant role in the process.

Table 6. Length (cm) of roots of selected citrus species stem cuttings as applied with different rooting hormones 60 days after planting. USM, Kabacan, Ctabato, 2019.

Hormones	Citrus Cutting			B-Mean [1/]
	Calamansi	Calamandarin	Dalandan	
Control	2.13	2.64	2.22	2.33[b]
IBA	4.34	4.32	3.13	3.93[ab]
IAA	5.82	2.75	2.82	3.80[ab]
NAA	5.55	3.81	4.16	4.51[a]
Hormex	6.58	3.72	2.56	4.29[a]
Saredex	4.6	2.91	3.02	3.51[ab]
A- Mean [2/]	4.84[a]	3.36[b]	2.99[b]	**3.73**

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C.V. - % 32.16

1/ Means with the same letter superscript are not significantly different at 5% level of significant (Tukeys-test)
2/ Means of citrus species with the same letter superscript are not significantly different at 5% level of significant (Tukeys-test)

Percentage Rooting

There were no significant interaction effects between two factors on rooting percentage of selected citrus species cuttings applied with different rooting hormones as shown in Table 7.

Analysis of variance revealed that there were significant effects among treatment means on the rooting percentage. Naphthalene Acetic Acid (NAA) was significantly different to untreated cuttings but comparable to all rooting hormones applied. Indole Butyric Acid (IBA), Indole Acetic Acid (IAA), Hormex and Saredex had no significant differences and were comparable to control. There were significant effects of citrus species on percentage rooting. The result implied that Dalandan cutting had better performance in rooting percentage than Calamansi and Calamandarin cuttings but both Calamandarin and Calamansi were comparable.

Maximum rooting and shoot growth characters have been recorded below IBA concentration of 500ppm (Singh *et al.,* 2015). Bhusal (2001) showed that the ability to root varied between species and varieties (0-100 %).

There was 100% rooting of rough lemon, while Tengu and Kuno satsuma mandarin had 0%. Root initiation is temperature driven but subsequent root growth was strongly dependent on available carbohydrates present in the cuttings. Control of temperature was a must and very important factor in the rooting of cuttings since cuttings with leaves should be handled carefully to prevent desiccation and the rooted under condition which be avoided excessive water loss from the leaves. Temperature was maintained during rooting between 23 to 27 ^{o}c at the base of cutting and 30 to 32 to ambient, without detriment to rooting (Hartmann *et al.,* 1997).

Table 7. Percentage (%) rooting of selected citrus species stem cutting as applied with different rooting hormones 60 days after planting. USM, Kabacan, Ctabato, 2019.

Hormones	Citrus Cutting			B-Mean[1/]
	Calamansi	Calamandarin	Dalandan	
Control	20.0	15.0	43.3	26.11^{b}
IBA	60.0	46.7	53.3	53.33^{ab}
IAA	53.3	40.0	46.7	46.67^{ab}
NAA	53.3	33.3	90.0	58.87^{a}
Hormex	30.0	33.3	56.7	40.00^{ab}
Saredex	33.3	30.0	46.7	36.67^{ab}
A- Mean[2/]	41.65^{b}	33.05^{b}	56.12^{a}	**43.61**

C.V. - % 45.19

1/ Means of rooting hormones with the same letter superscript are not significantly different at 1% level of significant (Tukeys-test)
2/ Means of selected citrus species with the same letter superscript are not significantly different at 1% level of significant (Tukeys-test)

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Percentage Survival

The percentage survival of selected citrus species cuttings applied with different rooting hormones at 60 days after planting is presented in Table 8,. Formation of buds, leaves, shoots and roots were considered as viable cuttings.

There were no interaction effects between selected citrus species and rooting hormones. But analysis of variance revealed that there were significant effects among treatment means. Rooting hormones mean cuttings treated with IAA got a 95.56% survival rate and were comparable to cuttings treated with IBA, IAA, NAA and Hormex had a survival rate from 92.22% to 93.33% that were significantly different from untreated with survival rate of 82.21%. Moreover, Saredex survival rate of 90% was comparable to the control. In selected citrus means, analysis of variance showed significantly different results. It was revealed that Calamansi and Dalandan were comparable with mean of 97.22% which was significantly different from Calamandarin with 78.89% survival.

The result implied that citrus species cuttings applied with rooting hormones performed better root development which led to higher percentage survival. In Singh's (2018) study of citrus production through cuttings, he observed that cuttings treated with high IBA concentration had the best rooting and survival percentage performance, whereas the mist house growing condition was found to be effective in increasing the cuttings success rate.

Table 8. Percentage (%) survival of different Citrus sp. stem cutting as applied with different rooting hormones 60 days after planting. USM, Kabacan, Ctabato, 2019.

Hormones	Citrus Cutting			B-Mean[1/]
	Calamansi	Calamandarin	Dalandan	
Control	83.30	76.70	86.7	82.21[b]
IBA	100.00	76.70	100.0	92.22[a]
IAA	100.00	90.00	96.7	95.56[a]
NAA	100.00	80.00	100.0	93.33[a]
Hormex	100.00	80.00	100.0	93.33[a]
Saredex	100.00	70.00	100.0	90.00[ab]
A- Mean[2/]	97.22[a]	78.89[b]	97.22[a]	**91.11**
C.V. - %	6.68			

[1/] Means of rooting hormones with the same letter superscript are not significantly different at 5% level of significant (Tukeys-test)

[2/] Means of citrus species with the same letter superscript are not significantly different at 5% level of significant (Tukeys-test)

OTHER OBSERVATIONS

Number of Rooted Citrus Cuttings

The numbers of rooted cuttings were observed at 30, 45 and 60 days after treatment. After 30, 45 and 60 days after planting, three 3 sample cuttings were destructed to get the number of rooted cuttings as shown in Table 9,. At 30 DAP application, after uprooting, Calamansi treated with IBA, IAA and NAA had the presence of roots with 2, 1, and 1, respectively while cuttings treated with hormex, saredex and control did not produced root. Dalandan treated with IAA and NAA produced only 1 rooted cutting while in Calamandarin treated with IAA had the presence of root. After 45 DAP application, 3 samples uprooted from all treatments. Cuttings treated with IBA, IAA and NAA, the 3 samples uprooted produced roots while Hormex, Saredex and control, only produced one rooted cutting. The least number of rooted cuttings were found in Calamandarin treated with NAA and Hormex , while cuttings treated with IAA had the most number of rooted cuttings. Moreover, Dalandan cuttings, all treatments

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produced rooted cuttings. Upon termination of the study, all selected citrus species formed roots in all hormone treatments. Dalandan had the highest number of rooted cuttings, followed by Calamansi and Calamandarin with 14 and 12 rooted cuttings, respectively

Table 9. Number of rooted citrus species as applied with different rooting Hormones at 30, 45 and 45 days after planting. USM, Kabacan, Ctabato, 2019

CITRUS	Days			Total Rooted Cuttings
	30	45	60	
Calamansi				
Control	0	1	1	2
IBA	2	3	2	7
IAA	1	3	3	7
NAA	1	3	4	8
Hormex	0	1	2	3
Saredex	0	1	2	3
Calamandarin				
Control	0	0	2	2
IBA	0	2	1	3
IAA	1	3	3	7
NAA	0	1	1	2
Hormex	0	1	2	3
Saredex	0	3	4	7
Dalandan				
Control	0	2	4	6
IBA	0	3	3	6
IAA	1	3	2	6
NAA	1	3	4	8
Hormex	0	3	4	7
Saredex	0	3	3	6

Temperature and Relative Humidity

The data on temperature and relative humidity is presented in Table 9, Plate 17. Temperature ranged from 32.1^{o}C in the morning to 38.2 ^{o}C during noon time and 33.3 ^{o}C in the afternoon while the relative humidity ranged from 96.3% to 97%.

In asexual propagation by cuttings, the main problem was keeping the cuttings from decaying and drying until the missing organ is generated, resulting in a new individual plant. The essential environmental requirements are proper temperature (not higher than 27 ^{o}c), very humid atmosphere (85 to 100% relative humidity), and ample light and clean, moist, well aerated and well drained rooting medium.

The temperature that is too high for normal growth caused physiological disorders by inhibiting or inactivating certain enzyme systems and possibly accelerating other systems. They also caused protein denaturation and coagulation, disruption of cell membrane and eventual death of cell. Damage by high temperature is increased several folds by lack of moisture and too intense light (Bautista *et al*., 1983).

Volume: 10 | Issue: 6| June 2022 | Journal DOI: 10.36713/epra0813| Impact Factor SJIF (2021) : 7.604| ISSN: 2321 - 7847

Table 10. Average Temperature and Relative Humidity of Experimental Area, USMARC,Kabacan, Cotabato

Month	Temperature (^{o}C)			Relative Humidity (%)		
	9am	12nn	3pm	9am	12nn	3pm
Jan	30.2	35.2	32.0	96.0	97.0	96.0
Feb	33.6	40.6	35.5	97.0	97.0	97.0
Mar	32.7	39.2	32.8	96.0	97.0	96.0
Average	**32.2**	**38.3**	**33.4**	**96.3**	**97.0**	**96.3**

CONCLUSION

The results of the study are summarized as follows: there were no significant interaction effects between the selected citrus species and different rooting hormones in all parameters at 60 days after treatment. Different hormones had significant effect on number of roots, length of roots, rooting percentage, percentage survival and length of shoots whereas not significant on days to shoots, length of shoot and number of leaves. Citrus cuttings had significant effect as to rooting percentage, length of roots, number of leaves, days to shoot and length of shoots while no significant effect was observed as to number of roots and number of shoots.

All rooting hormones improved the rooting performance of selected citrus species. Naphthalene Acetic Acid performed better in term of rooting percentage, length of roots and number of days to shoot emergence. Indole Acetic Acid also performed better in percentage survival and length of shoots, while IBA performed better in number of roots. Hormex performed better in number of shoots and number of leaves.

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